Using Map Mashups in Map Projection Education

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Abstract. Map mashups created by Google Maps API are used in many web sites, where maps are needed. In this study, the use of map mashups in cartography education, especially in map projection education, is focused on. In order to help students to understand the properties of great circles and rhumb lines, a web page, named cartographic calculator, is created. Students can do some calculations –direct solution and inverse solution on the sphere- with this web page, and see the points and lines on the map. With help of calculation and visualization possibilities students can better understand the properties of great circles and rhumb lines. To evaluate the efficiency of the cartographic calculator, two groups of students taking the cartography course at Selcuk University are formed. The test group uses the Cartographic Calculator, the control group uses conventional materials. After pre and final examinations the groups are compared.

Keywords: Map Projections, Map Mashups, Rhumb Line, Great Circle

1. Introduction

Location based or spatial contexts are becoming more and more common in the World Wide Web with the introduction of Web 2.0, which refers to technological and contextual changes how software developers and end-users use the Web. Some examples of Web 2.0 are social networking sites, blogs, wikis, video sharing sites, hosted services, web applications, mashups and folksonomies. Mashups being a tool in web development play an important role in the map dissemination through Web. A mashup is a web page, or web application, that uses and combines data, presentation or functionality from two or more sources to create new services. The term implies easy, fast integration, frequently using open application program-

ming interfaces (API) and data sources to produce enriched results. It isn't formally defined by any standard-setting institution. The first mashups used mapping services or photo services to combine these services with data of any kind and therefore create visualizations of the data. In the beginning, most mashups were consumer-based, but recently it is to be seen as a technology useful also to enterprises. Business mashups can combine existing internal data with external services to create new views on the data. End users of the Web face map mashups in their everyday life. Most popular map mashups and API's are Google Maps, Yahoo Maps, Bing Maps (URL0, Li and Gong 2008).

Map mashups can also be used for educational purposes. Some calculations in cartography or map projection courses can be combined with a map, for instance. So the students can see their results on a map. In conventional teaching, students do some calculations without knowing where the points are. In this paper, we focus on a topic in map projections: Lines of special properties, i.e. great circles and rhumb lines. A web page, called cartographic calculator (CC), is developed for doing some calculations about great circles and rhumb lines. Basically, direct and inverse solution problems are taken into account. Using a JavaScript code, location of the second point, or the great circle and/or rhumb line distance and the azimuth between two points are calculated. At the same time lines and points are displayed on the map. In order to evaluate the efficiency of this web page, two groups of students who take the cartography course at Geomatics Division of Selcuk University are formed. One group used CC, other group used conventional materials (course book and presentations used by the lecturer). With help of pre- and after tests the groups are compared.

2. GoogleMaps API

Google Maps has a number of APIs that enable web developers to embed the functionality of Google Maps into their own websites and applications, and overlay their own data. The Google Maps API family consists of the following tools (URL 2):

- JavaScript API v3: You can embed an interactive Google Map in your webpage using JavaScript.
- Maps for Business: Google Maps API for Business provides Enterprise-ready application support for your mapping needs.
- Google Maps SDK for iOS: Google Maps can be added to iOS apps, with rotation, tilt & 3D buildings.
- Maps Android API: Interactive, vector-based maps can be added to Android applications.

- Web Services: URL requests can be used to access geocoding, directions, elevation, place and time zone information.
- Places API: Information about establishments, geographic locations, or prominent points of interest can be obtained.
- Maps Image APIs: A Google Maps image or Street View panorama can be embedded in any web page without requiring JavaScript.
- Google Earth API: Google Earth can be accessed without leaving the web page.

All these tools are free services, if a web site is free to all consumers. Businesses that charge fees for access, track assets or build internal applications must use Google Maps for Business, which provides enhanced features, technical support and a service-level agreement.

Google Maps API Family is used with JavaScript, the most popular scripting language for developing dynamic web content. Its use is also free.

The datum of the map data is WGS 84. The maps are portrayed in the Mercator projection. Due to increasing distortion towards poles, Polar Regions are not shown, so the world is portrayed between ~85 N and ~85 S latitudes. In terms of scale, there are 18 zoom levels ranging from a map scaled ~1:5000 to a world map scaled ~1:250 million. For each level certain objects are selected and generalized accordingly. A comprehensive summary about Google Maps and Maps API can be found in URL 1.

3. An Online Education Material: Cartographic Calculator

One of the topics taught in cartography or map projection courses is lines of special properties on the sphere, i.e. great circles and rhumb lines. The former provides the shortest distance on the sphere; the latter intersects all the meridians at constant azimuth. In general, students learn some calculations like great circle distance between two points without knowing the locations of points. If they see the points and the lines connecting them on a map, they will better understand the geometry of the sphere. Inspiring from this idea, a dynamic web page is developed, with which users can do calculations and see their results on map. This page is called cartographic calculator (CC).

Basically, CC handles direct and inverse solution problem on the sphere. Both calculations can be done if points are connected with a great circle, or a rhumb line (Figure 1).

3.1. Direct and Inverse Solution with a Great Circle connecting Points

The great circle distance between two points on the sphere is the shortest distance between them. So, the direct and inverse solution term is mostly used for this problem. The triangle P_1NP_2 (Figure 1, left) is a spherical triangle. The problem can be solved by using spherical trigonometry.

In the direct solution problem, geographical coordinates of a point (P_1), the azimuth at this point and the great circle distance are known, and geographical coordinates of the second point (*P2*) are needed. The azimuth at P_2 is also needed. The solution (Richardus and Adler 1972):

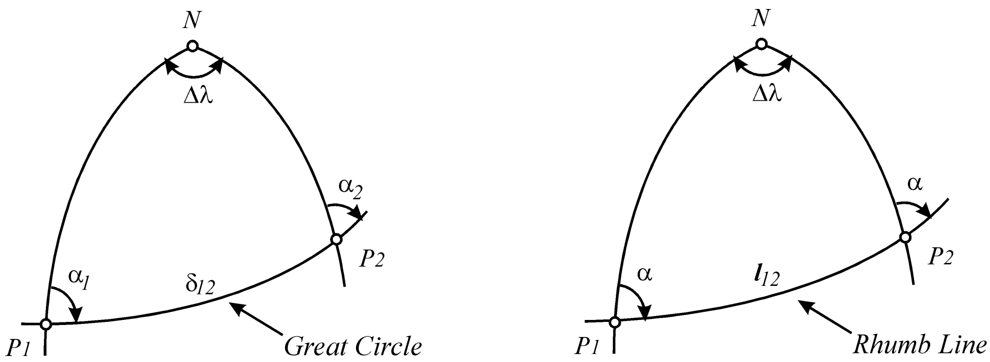

Figure 1. Direct and inverse solution (left: points connected by great circle right: by rhumb line)

$$
\begin{aligned}
&\sin\varphi_2 = \sin\varphi_1 \cos\delta_{12} + \cos\varphi_1 \sin\delta_{12} \cos\alpha_1 \\
&\tan(\lambda_2 - \lambda_1) = \frac{\sin\alpha_1}{\dfrac{\cos\varphi_1}{\tan\delta_{12}} - \sin\varphi_1 \cos\alpha_1} \\
&\cos\alpha_2' = -\cos\alpha_1 \cos(\lambda_2 - \lambda_1) + \sin\alpha_1 \sin(\lambda_2 - \lambda_1)\sin\varphi_1 \\
&\alpha_2 = \pi - \alpha_2'
\end{aligned}
\tag{1}
$$

The range of angles should be considered in the usage of inverse trigonometric functions.

$$
\frac{\pi}{2} \le \varphi_2 \le \frac{\pi}{2} \quad -\pi \le \Delta\lambda \le \pi \quad 0 \le \alpha_2 \le 2\pi \tag{2}
$$

In the inverse solution problem, the geographical coordinates of two points are known, the great circle distance and the azimuths at P_1 and P_2 are needed. The solution (Richardus and Adler 1972):

$$
\delta_{12} = R\arccos(\sin\varphi_1 \sin\varphi_2 + \cos\varphi_1 \cos\varphi_2 \cos(\lambda_2 - \lambda_1))
$$

$$
\tan\alpha_1 = \frac{\sin(\lambda_2-\lambda_1)}{\cos\varphi_1\tan\varphi_2-\sin\varphi_1\cos(\lambda_2-\lambda_1)}
$$
$$
\cos\alpha_2' = -\cos\alpha_1\cos(\lambda_2-\lambda_1)+\sin\alpha_1\sin(\lambda_2-\lambda_1)\sin\varphi_1 \qquad (3)
$$
$$
\alpha_2 = \pi-\alpha_2'
$$

3.2. Direct and Inverse Solution with a Rhumb Line Connecting Two Points

Direct and inverse solution can also be applied to a rhumb line connecting two points on the sphere. Because a rhumb line is not a great circle, the triangle P_1NP_2 (Figure 1, right) is not a spherical triangle. The spherical trigonometry can not be employed here; instead, a solution by using basic principles of differential geometry is possible. Below the final formulae are given (For details see Richardus and Adler 1972).

In the direct solution, the geographical coordinates of a point (P_1), the azimuth and the rhumb line distance are given, and the geographical coordinates of the second point are needed. The solution:

$$
\varphi_2 = \varphi_1 + \frac{\ell_{12}\cos\alpha}{R}
$$
$$
\lambda_2 = \lambda_1 + \tan\alpha\left[\ln\tan\left(\tfrac{\pi}{4}+\tfrac{\varphi_2}{2}\right)-\ln\tan\left(\tfrac{\pi}{4}+\tfrac{\varphi_1}{2}\right)\right] \qquad (4)
$$

In the inverse solution, the geographical coordinates of two points are known (P_1 and P_2), and the azimuth and rhumb line distance are needed. The solution:

$$
\tan\alpha = \frac{\lambda_2-\lambda_1}{\ln\tan\left(\tfrac{\pi}{4}+\tfrac{\varphi_2}{2}\right)-\ln\tan\left(\tfrac{\pi}{4}+\tfrac{\varphi_1}{2}\right)}
$$
$$
\ell_{12} = \frac{R}{\cos\alpha}(\varphi_2-\varphi_1) \qquad (5)
$$

It should be noticed that the range of the azimuth is between 0 and 2π. For all calculations in which inverse tangent function is needed the atan2 function is suggested if available. It is available in programming languages such as C/C++ and Java and spread sheet software.

3.3. Cartographic Calculator Web Site

The cartographic calculator (CC) web site or web page is developed with JavaScript and Google Maps API (JavaScript API). It includes a map object, buttons and text boxes. The main purpose of CC is to do computations

about direct and inverse solution with great circles and rhumb lines. It is coded by using JavaScript and Google Maps API v2. CC is available in two languages (Turkish and English).

In the map three types are available: map, satellite and terrain (a physical map). If the GoogleEarth plugin is installed, an earth view will also be available, in which users see a virtual globe. GoogleMaps uses the Mercator Projection -a conformal cylindrical projection-, in which rhumb lines are displayed as straight lines. Due to map projection distortions, great circles appear as curves, longer than rhumb lines. The earth view enables users to see the rhumb lines and great circles on the globe in their true relationships. Here great circles appear as is (shorter than rhumb lines). It is a great opportunity that users see such interesting relationships on the map and on the globe (earth view). In Figure 2 and 3 the great circle distance and the rhumb line distance between two arbitrary points are shown in map and earth view.

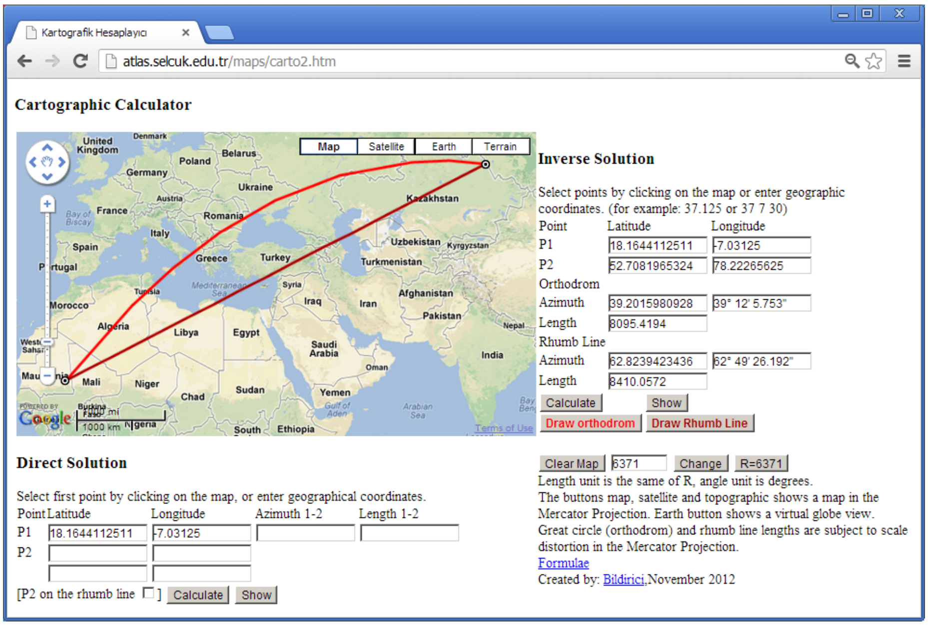

Figure 2. The cartographic calculator web site (URL3)

For educational purposes such a web site as CC may enable students to understand the geometry of the sphere and lines of special properties on the sphere (great circles, small circles, rhumb lines). At the same time, students can enhance their computational skills.

The default value for earth radius is 6371km, which is the radius of authalic sphere of the WGS84 ellipsoid. The length unit is dependent on the radius. Users may enter a radius value in meters or in any other unit.

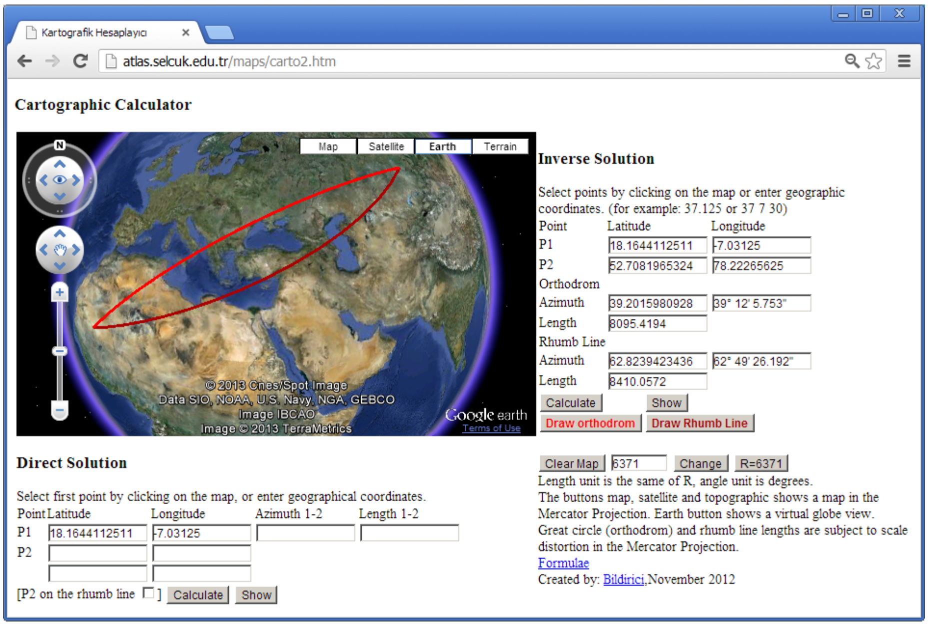

Figure 3. Earth View in the CC

4. Efficiency of CC

In order to evaluate the efficiency of CC, a study is realized with students. Two groups were formed, a test group who uses CC, and a control group who uses conventional materials. Both groups took an examination at the beginning (a pretest). Then, a short course about 2 hours was given, for each group. In the course of test group, CC was mentioned. In the second group conventional materials were used. A home work was given to both groups. After one week, home works were collected and the groups took a final examination. Both examinations consist of 10 multiple-choice questions. The homework requires computations about direct and inverse solutions. In table 1, the final results are shown. It is interesting that the control group is more successful. The test group is only better in the home work. It is not surprising because they have the possibility to check their results by using CC.

Considering the results of the pretest, it can be said that there is a significant difference between the groups. The control group possibly consists of

more successful students. Due to this difference at the beginning the results are not as expected.

	Number of Students	Pretest	Homework	Final Test
Test Group	11	%42	%42	%43
Control Group	10	%62	%20	%69

Table 1. The scores of the test and control groups

5. Conclusion

Map mashups are powerful tools in terms of Internet mapping. They are becoming more and more popular. They are used in many areas where maps are needed. This technology can also be used for educational purposes. In this paper, the educational use of this technology is considered. A web page is created for some computations about direct and inverse solution problem that is a topic in cartography or map projection courses. By using this page, students can improve their computational skills and understandings about the relationships and the structure of great circles and rhumb lines on the sphere.

The web page is called Cartographic Calculator (CC) and is published under URL 3. Their efficiency is tested with students. Due to the different level of the student groups at the beginning, the results are not enough to evaluate the efficiency of the CC. In near future we repeat the efficiency tests with different group of students. We also plan to extend the functionality of CC adding more calculations from map projection and mathematical geodesy topics.

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